EXAMINATION OF CUTTING KNEE MECHANICS USING PRINCIPAL COMPONENTS ANALYSIS

Kristian O'Connor and Michael Bottum

Department of Human Movement Sciences
University of Wisconsin-Milwaukee, Milwaukee, WI, USA
E-mail: krisocon@uwm.edu Web: www.chs.uwm.edu/neuromechanics

INTRODUCTION

Several studies have identified a disparity of non-contact anterior cruciate ligament (ACL) injury rates between males and females engaged in similar physical activities. Determining the nature of how interaction of external and internal factors creates a higher likelihood of injury in females has experienced mixed findings. Typical studies have been limited to discrete measures of kinematic and kinetic variables, with lack of consensus on the most relevant set of dependent variables (e.g., Pollard et al., 2004; McLean et al., 2004).

A cutting maneuver may be viewed as a complex coordinated task between multiple musculoskeletal components and the nervous system. Daffertshofer (2004) suggested that multivariate analysis methods, such as principle component analysis (PCA), which examine the entire spectrum of multidimensional waveform data, might more accurately identify embedded patterns of complex movements. Although widely viewed in statistical fields as a powerful data reduction tool, PCA's application to biomechanical problems has been slow to take hold, despite having shown promise in identifying pathological movement (Deluzio et al. 1997) and loading (Wrigley et al., 2006) patterns. PCA, due to its ability to extract modes of variability (principle components, or PCs) from complex data sets, may be better suited to recognize differences between male and female joint dynamics. The purpose of this study was to identify functional differences in knee dynamics during an unanticipated cutting maneuver using principal components analysis.

METHODS

Seventeen male and sixteen female recreationally active individuals participated in this study. Each subject was asked to perform five trials of a randomly cued running and cutting maneuver. Three-dimensional kinematic data were collected using a seven-camera Motion Analysis Eagle system (200 Hz), and force data were collected using an AMTI force platform (1000 Hz). Resulting three-dimensional knee kinematic and kinetic data was time normalized to 100% of stance (101 data points). Touchdown angles, ranges of motion, and peak moments were extracted. For the PCA analysis, each individual trial served as an input to the PCA (33 subjects $\times$ 5 trials = 165 trials – 12 discarded trials = 153 total trials). The data were compiled into a 153$\times$101 matrix for each joint variable (3 angles and 3 moments). PCA was performed on each variable in the manner described by Wrigley et al. (2006) using Matlab v7.3. Parallel analysis was used to determine the number of PCs to retain for each variable. Eigenvector scores were calculated for each trial, and a mean of the scores was generated for each subject for each retained PC. Two-tailed t-tests were performed on the discrete measures and on the subject mean eigenvector scores between genders ($p<0.05$).

RESULTS AND DISCUSSION

Parallel analysis revealed four to seven PCs (modes of variation) accounting for 96.8% of the explained variance of each of the six joint variables. In the frontal plane, there were no significant differences between genders for the TD angle, ROM, or peak moments (Figure 1). However, there were significant differences between genders for PC2 for both angle and moment data. PC2 identified a high frequency angle oscillation during early stance (Figure 1). In the sagittal plane, the peak flexion angle differed, which was also captured by PC1. In the transverse plane, TD angle and ROM were different, which was captured by PC1 and PC3. The peak transverse plane moment was not different, but PC2 detected significant differences between genders.

Principal component analysis was able to detect pattern differences between genders that were not always identified by traditional discrete measures. This technique identified significantly greater angle oscillations in the frontal plane for females. These differences may be clinically relevant based on previous findings highlighting the importance of the frontal plane. PCA provides potential in avoiding the need to specify a set of dependent variables a priori and can automatically identify relevant functional patterns.

REFERENCES

Daffertshofer,A. et al. (2004). *Clinical Biomechanics*, **19**, 415-428.

Deluzio,K.J. et al. (1997). *Human Movement Science*, **16**, 201-217.

Pollard et al. (2004). *Clinical Biomechanics*, **19**, 1022-1031.

McLean et al. (2004). *MSSE*, **36,** 1008-1016.

Wrigley,A.T. et al. (2006) *Clinical Biomechanics*, **21**, 567-578

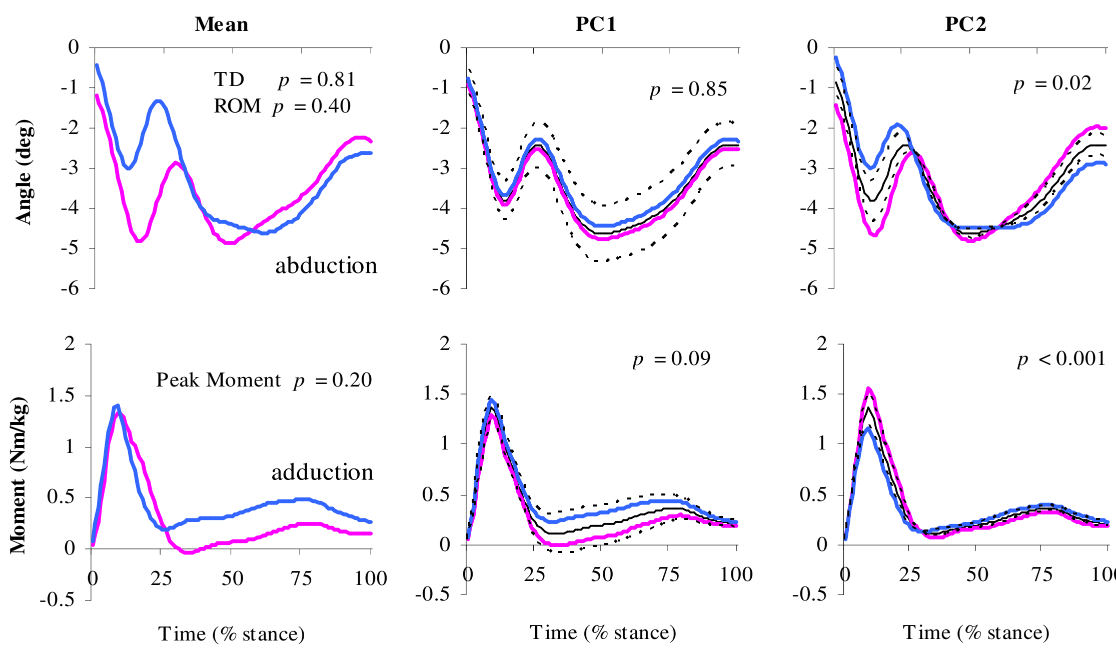

Figure 1: Group mean frontal plane angle and moment data for males (blue) and females (pink) with the p-values of discrete (TD angle, ROM, and peak moment) and PC-score gender comparisons. PC1 and PC2 demonstrate the extracted patterns with the black solid line representing the overall group mean. The dashed lines represent the between-subjects standard deviation of the PC scores' effect on PC coefficients, and the lines for each gender represent their average PC score-coefficient relationship.